Resonant atomic switching near a photonic band-gap: Towards an all-optical micro-transistor

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We describe the spectral characteristics of the radiation scattered by two-level atoms (quantum dots) driven by a strong external field, and coupled to a photonic crystal radiation reservoir. We show that in the presence of strong variations with the frequency of the photonic reservoir density of states, the atomic sideband components of the scattered intensity can be strongly modified. Consequently, a weak optical probe field experiences a substantial differential gain in response to slight variations in the intensity of an optical driving field. Using a specific photonic crystal heterostructure, we suggest that an all-optical micro-transistor based on photonic crystals may operate at less than 100 nW switching threshold power. Collective *N*-atom effects substantially enhance this optical switching effect and correspondingly reduce the switching time scales of the atomic system in response to external fields. We analyze the effects of the inhomogeneous atomic line broadening on the amplification process. We show, using suitable photonic density of states engineering, that it is possible to select a narrow spectral range around the central frequency of the atomic frequency distribution over which amplification and switching occur.

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